AVHRR-Based Polar Pathfinder Products: Evaluation, Enhancement and Transition to MODIS

(NASA Grant: NAG5-6666)

Co-PIs: Charles Fowler, James Maslanik, Robert Stone, Julienne Stroeve, William Emery

1. OVERVIEW

The AVHRR-Based Polar Pathfinder (APP) products include calibrated AVHRR channel data, surface temperatures, albedo, satellite scan and solar geometries, and a cloud mask composited into twice-per-day images, and daily averaged fields of sea ice motion, for regions poleward of 50 deg. latitude.

Our goals under this grant, in general, are four-fold:

- To quantify the APP accuracy and sources of error by comparing Pathfinder products with field measurements.
- To determine the consistency of mean fields and trends in comparison with longer time series of available station data and forecast model output.
- To investigate the consistency of the products between the different AVHRR instruments over the 1982-present period of the NOAA program.
- To compare an annual cycle of the AVHRR Pathfinder products with MODIS to establish a baseline for extending Pathfinder-type products into the new ESE period.

Year One tasks include intercomparisons of the Pathfinder products with field measurements, testing of algorithm assumptions, collection of field data, and further validation and possible improvement of the multi-sensor ice motion fields. Achievements for these tasks are summarized below.

2. FIRST YEAR ACCOMPLISHMENTS

2.1 Comparisons with Observations and Models

The APP albedo product is derived from AVHRR channels 1 and 2, normalized with solar zenith angle, and corrected for water vapor and atmospheric aerosols and anisotropic reflection, and converted into a broadband albedo. The APP algorithms used to date depend upon published work based on field investigations and modeling. In our Year One comparisons with field data, one deficiency that we have found is that all such previous work has been limited to data with relatively high sun angles. However, a large percentage of the APP products have lower sun angles where many of the parameterization assumptions are less valid. The composited daylight albedo product shows discontinuities at adjacent orbits, which are not fully explained by the dependence of the albedo on solar zenith angle. AVHRR channel 1 and 2 radiances were simulated using the DISORT model and found to be in general agreement with the observed satellite measurements, but the existing zenith angle corrections and the conversion from narrow-band to broad- band albedo require improvement.

Another approximation used in the generation of the products is the application of similar atmospheric corrections over sea ice and ice sheets. Our Year One investigations indicate that the Pathfinder surface albedo is overestimated by about 10% over substantial portions of the ice sheets. Comparisons of the APP skin temperatures to field observations in Greenland also suggest a mean bias of approximately 3 K. The primary cause of these errors is believed to be the difference in elevation between sea level and the ice sheet surfaces in the standard APP algorithm, which yields an over-correction due to the assumption of total-atmospheric-column water vapor values appropriate for sea level.

Additional comparisons were done to test the consistency between the APP 5-km products (derived from AVHRR global area coverage (GAC) data), and the 1.25-km products from local area coverage (LAC) and high-resolution picture transmission (HRPT) data. The comparisons identified some

discrepancies in paramaterizations used in the two processing streams. These discrepancies were corrected, resulting in uniform products at the two resolution levels.

Further work has focused on assessing the accuracy of the APP cloud detection algorithm. A new approach was developed that makes better use of temporal change and which is better suited to the extensive areal coverage of the APP products.

2.2 Field Data Collection

In March of this year, one of this project's co-investigators participated in collecting surface based bi-directional reflectance distribution function (BRDF) measurements over snow using the PARABOLA instrument as part of the EOS MODIS field validation campaign. These data will serve as an evaluation set for improved APP BRDF corrections and will be used to re-examine the narrow to broadband conversion used in the APP algorithm.

At the Surface Heat Balance of the Arctic (SHEBA) experiment underway in the Beaufort and Chukchi seas, two of the Pathfinder Validation co-investigators used a sled-mounted instrument package to collect skin temperature and surface reflectance along transects coincident in time with AVHRR overpasses during April and May. These data will be combined with surface-based (SHEBA) and aircraft (SHEBA and FIRE) observations to investigate the accuracy of APP cloud detection and geophysical parameters.

2.3 Improvements and Extensions in the APP Sea Ice Motion Product

The APP ice motion product consists of remotely-sensed ice motion from AVHRR and passive microwave sensors, merged with daily buoy displacements. Additional comparisons have been done in Year One using buoy motions and sea ice modeling to quantify the nature of errors in the remotely-sensed products.

Initial attempts to obtain motions from Special Sensor Microwave/Imager (SSM/I) data by us and other investigators have been limited to the highest resolution channel (85 GHz). As part of the current project, a new motion algorithm is being tested which improves the 85 GHz-derived ice motions and allow motions to be estimated more accurately from lower-frequency channels. This improves retrievals during summer months and allows extension of the multi-sensor ice-motion fields for an additional nine years using Scanning Multichannel Microwave Radiometer (SMMR) data.

3. YEAR TWO TASKS

- Comparisons to field observations will include evaluations using SHEBA, BASE, additional Greenland observations, and existing data sets for Barrow, Alaska and the Antarctic. We plan to test alternative algorithms tailored to ice sheet conditions including use of an elevation model for processing over high-altitude land and ice sheets.
- Existing and alternative cloud detection procedures will be evaluated;
- Investigations will be extended to document data consistency between AVHRR satellites by comparing long time series and any existing overlaps between the satellites. This analysis will also encompass the newest NOAA AVHRR, NOAA-15 in the new modified K-L-M series.
- Given the EOS launch delay, we are investigating additional opportunities for APP product evaluation. Possibilities for supplemental data collection include observations made during the trans-Arctic ice-breaker cruise during 1994, collaboration with a Canadian study planned for Hudson Bay, as well as local measurements of snow temperatures and reflectance using the sled-mounted instruments developed for the SHEBA project.